NATIONAL STEEL AND SHIPBUILDING COMPANY

LEAPFROG TECHNOLOGY TO STANDARDIZE EQUIPMENT AND SYSTEM INSTALLATIONS

UNIVERSITY OF NEW ORLEANS SUBCONTRACT

NSRP 0537 PROJECT SP-6-95-2
SECTION NO.4 — BOUND THE PROBLEM

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4 BOUND THE PROBLEM

BOUND EQUIPMENT INSTALLATION PARAMETERS

This section describes and outlines the ranges of various parameters considered for Equipment Installations. The various methods, techniques and concepts of equipment installations to be later incorporated into the standards development are also discussed here. The equipment foundation and installation parameters were evaluated and a range for the variables was established which will be used to analyze and develop the standards. By bounding the parameters we have obtained min/max constraints and variations of the physical geometry, arrangements, installation parameters, ship structure interface scenarios, and effects of equipment installations' physical locations.

The equipment installations can be categorized into various standard foundation types. Vibtech has established 27 different standard foundation types, which will encompass almost all of the equipment installation types for shipboard application (see Figure 4-1). Of these standard foundation types, 3 are most frequent and are therefore adopted for the initial identification and bounding of the variables. These 3 foundation types are Grillage, Frame, and Truss, (see Figure 4-2, Figure 4-3, and Figure 4-4). Other than the standard foundation types, 18 different method mount types were also looked into to in order to bound the parameters. The most important issue addressed in this section is the development of improved designs that simplify the manufacture and installation of foundations and attachments, (see Figure 4-5, Figure 4-6, and Figure 4-7), that may be used to rapidly install or attach foundations to the ship's structure. While foundation standards are important in and of themselves, improved rapid attachment methods (see Figure 4-5, Figure 4-6, and Figure 4-7), will accelerate outfitting of foundations for equipment and will reduce overall construction time and hence the overall construction schedule.

General design parameters that affect the design such as loading, vibration, noise, fatigue, allowable stress, etc. were reviewed and a preliminary estimation of the effect of these parameters on design was done. Some of these estimations are elaborated in the report of Section 2.A.

The Grillage type foundations have been traditionally welded completely to the mounting surface; i.e., deck or bulkhead, (see Figure 4-2). Grillages can be designed to be lifted off the mounting plate, (see Figure 4-5), using a variety of attachment details. In that case they are similar to method mounts. Grillages completely welded on to the mounting plate may have backup structures like far-side headers, chocks, and brackets to increase its strength and rigidity. However, if the vibration and fatigue criteria are met, grillages may be directly attached to the soft mounting plate with minimum or no back-up structures.

The parameters for Grillages include:

- Mounting Plate (deck or bulkhead) Thickness – 3/16 to 3/4 inches
- Scantling Sizes – 2"x2"x3/16" to 4"x4"x1/2" Angles

The Frame type foundations have their legs completely welded to the ship structure, with adequate tie-up pieces (see Figure 4-3).

The parameters for Frame type foundations include:

- Mounting Angle Span Length – 10 to 50 inches
- Scantling Sizes – 2"x2"x3/16" to 4"x4"x1/2" Angles
- Frame Leg Length – 6 to 36 inches

The Truss type foundations are similar to the Frame type, except for the diagonal pieces bracing the legs to increase the lateral stiffness of the foundation (see Figure 4-4).

The parameters for Truss type foundations include:

- Mounting Angle Span Length – 10 to 50 inches
- Scantling Sizes – 2”x2”x3/16” to 4”x4”x1/2” Angles
- Truss Leg Length – 6 to 36 inches

The Method Mount Foundation types are basically variations of the Grillage type foundations lifted off the mounting plate (deck or bulkhead) and integrating the ship structure into its design for cost reduction (see Figure 4-5, Figure 4-6, and Figure 4-7). Some of the Method Mounts are designed for mounting multiple equipment on one integrated foundation.

The parameters for Method Mounts include:

- Mounting Angle Span Length – 10 to 50 inches
- Mounting Angle Overhang Length – 10 to 50 inches
- Mounting Plate Thickness – 3/16 to 3/4 inches
- Scantling Sizes – 2”x2”x3/16” to 4”x4”x1/2” Angles

The other 24 foundation types have some of their basic features similar to that of Grillage, Frame or Truss, along with some other attributes unique to them. These designs have been developed based on statistics of repeated use on a variety of ship types. The final standards incorporate all of these 27 foundation types as standard foundation types.

Apart from the foundation types made-up of steel sections, two other methods of equipment installations were also evaluated. They are Stud-mounted equipment (see Figure 4-6) and Spool-mounted equipment (see Figure 4-7). These two foundation types are the simplest ones, needing virtually no fabrication as they come in standard shapes and sizes, and are mostly used to mount light to medium weight equipment.

The parameters for Studs include:

- Mounting Plate Thickness – 3/16 to 3/4 inches
- Stud Sizes – 5/16” to 3/4”
- Stud Length – 1 to 12 inches

The parameters for Spools include:

- Mounting Plate Thickness – 3/16 to 3/4 inches
- Spool Sizes – 2.5” diameter to 4” diameter
- Spool Length – 3 to 12 inches
- Stud Sizes – 1/2” to 3/4”

The parameters of various equipment installation types and their respective min/max and ranges will be used as the starting point for the engineering analysis and standards development.

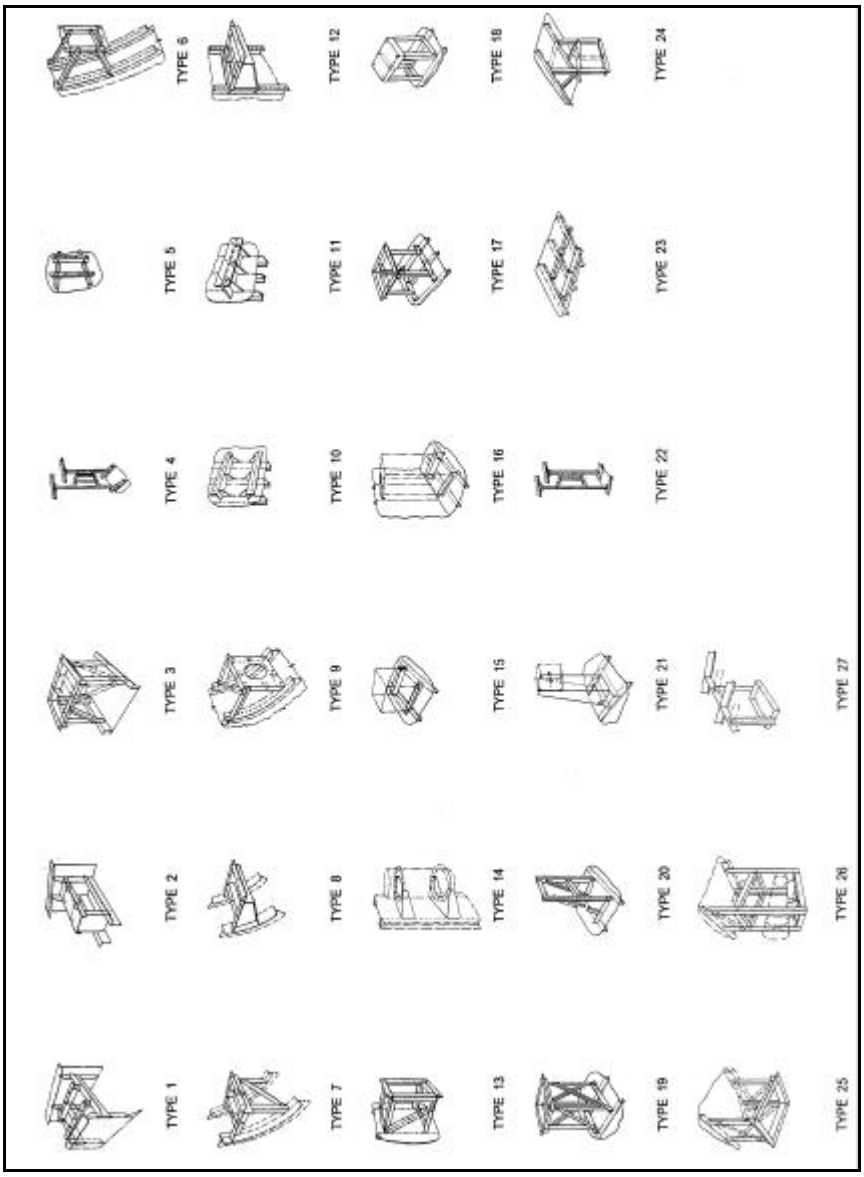


Figure 4-1 — Standard Foundation Types

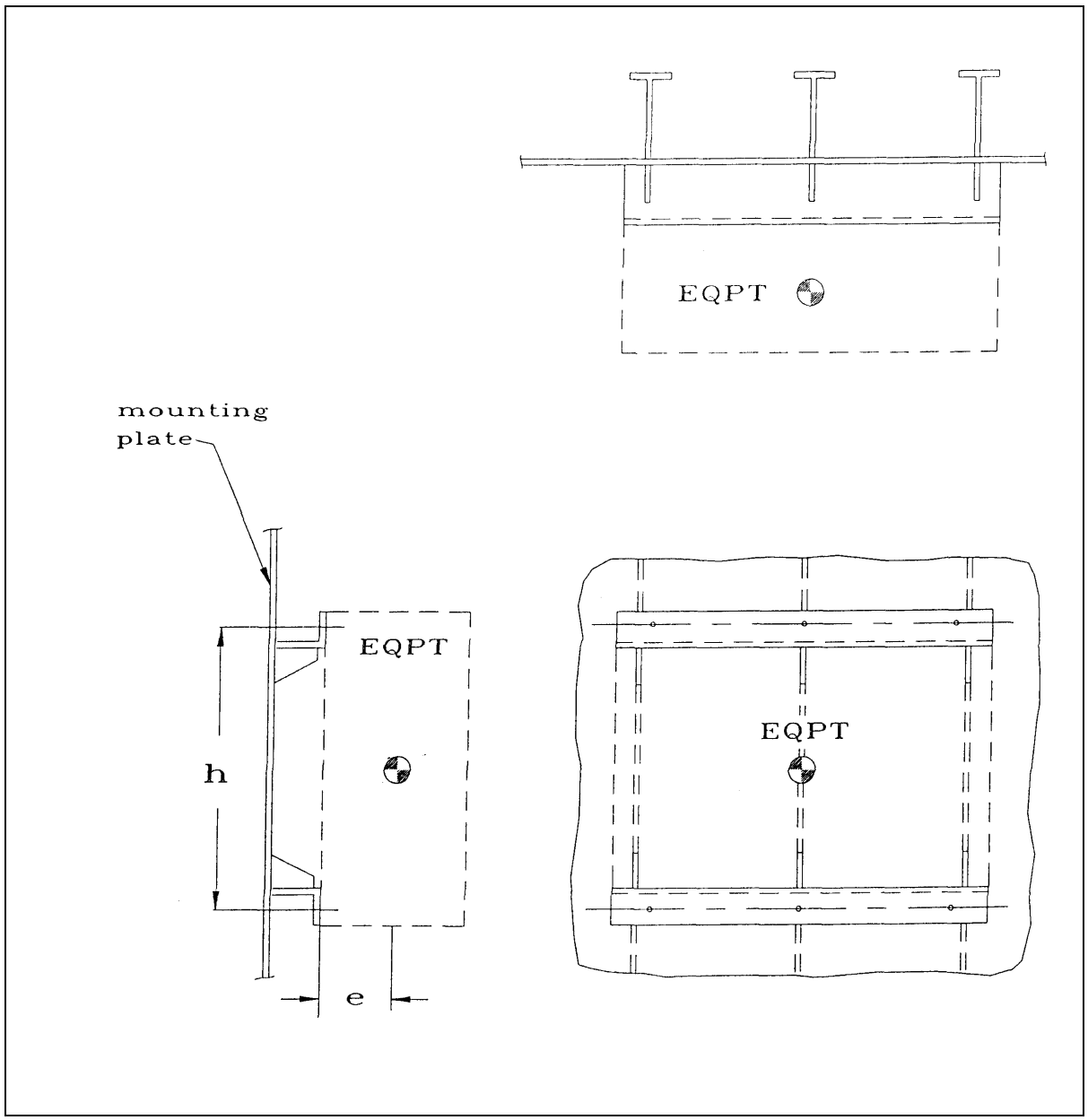


Figure 4-2 — Grillage

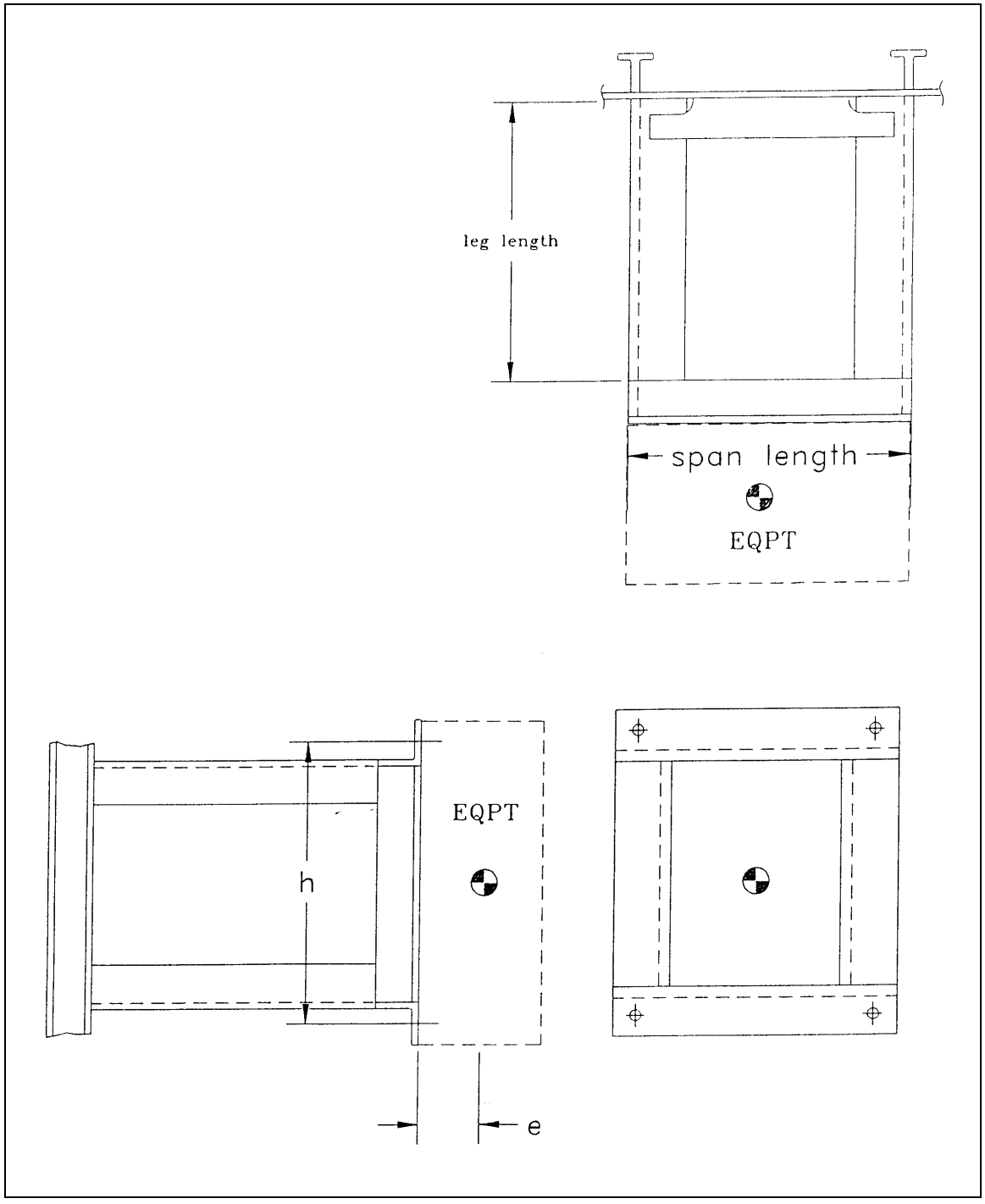


Figure 4-3 — Frame

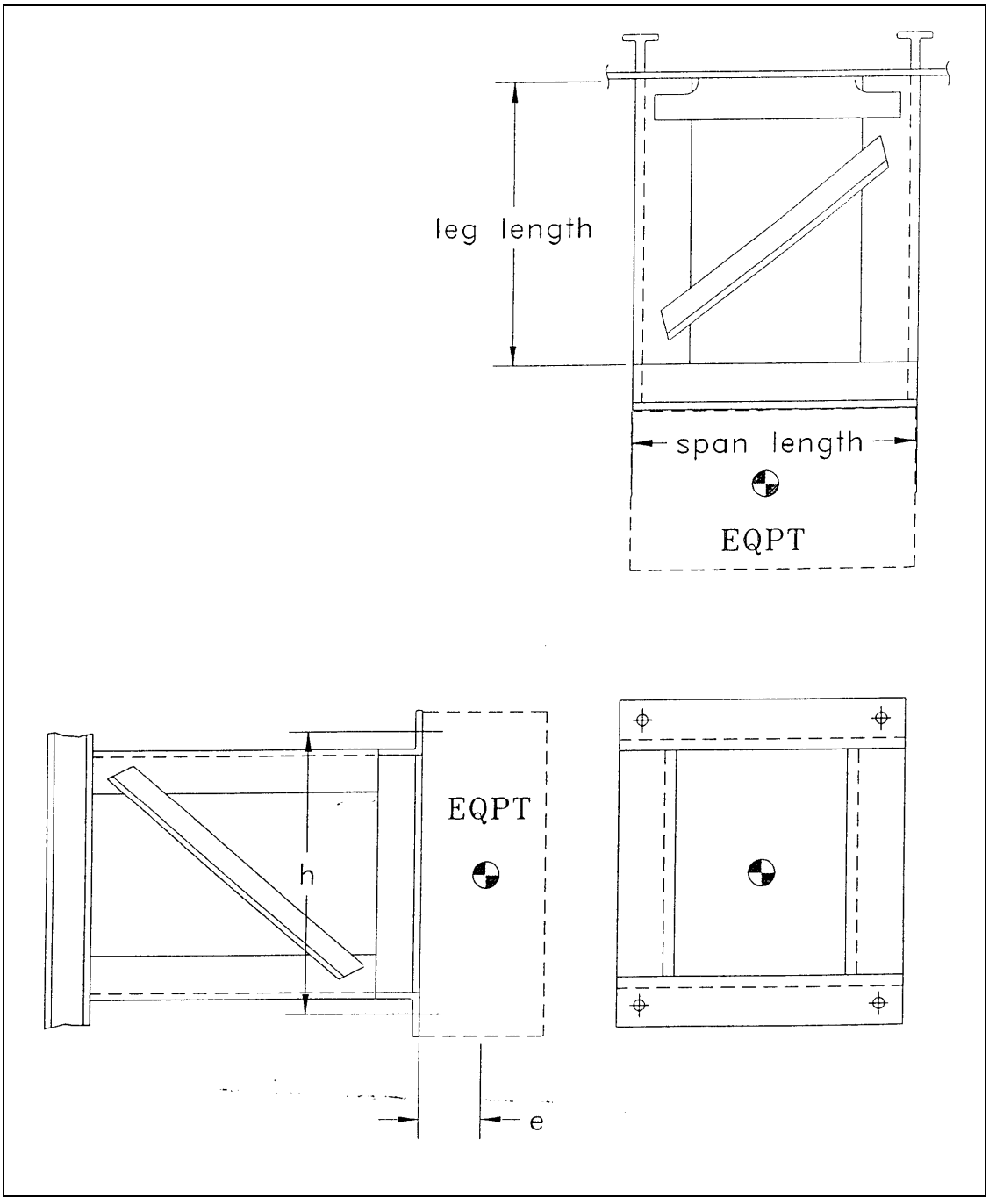


Figure 4-4 — Truss

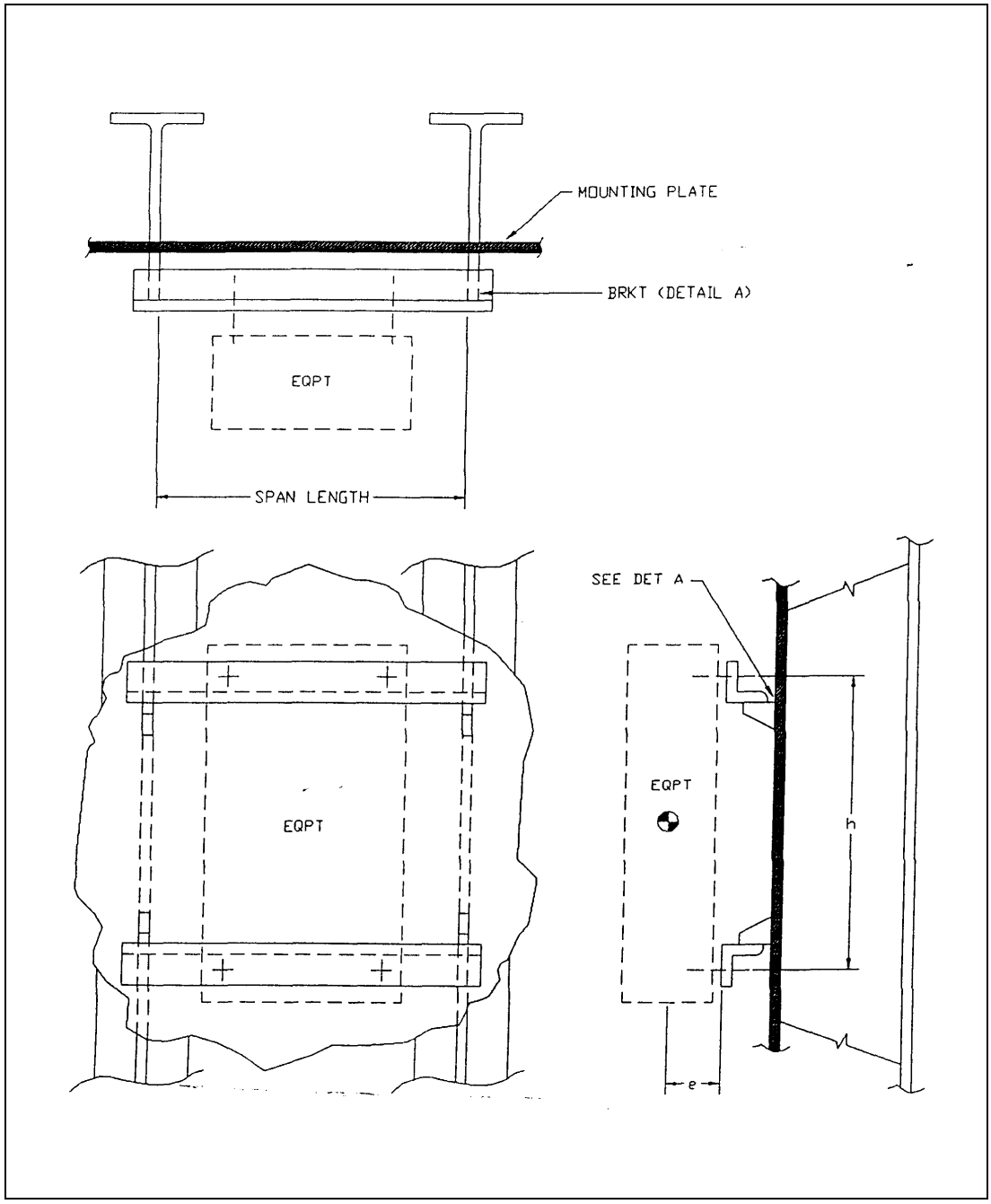


Figure 4-5 — Method Mount Illustration

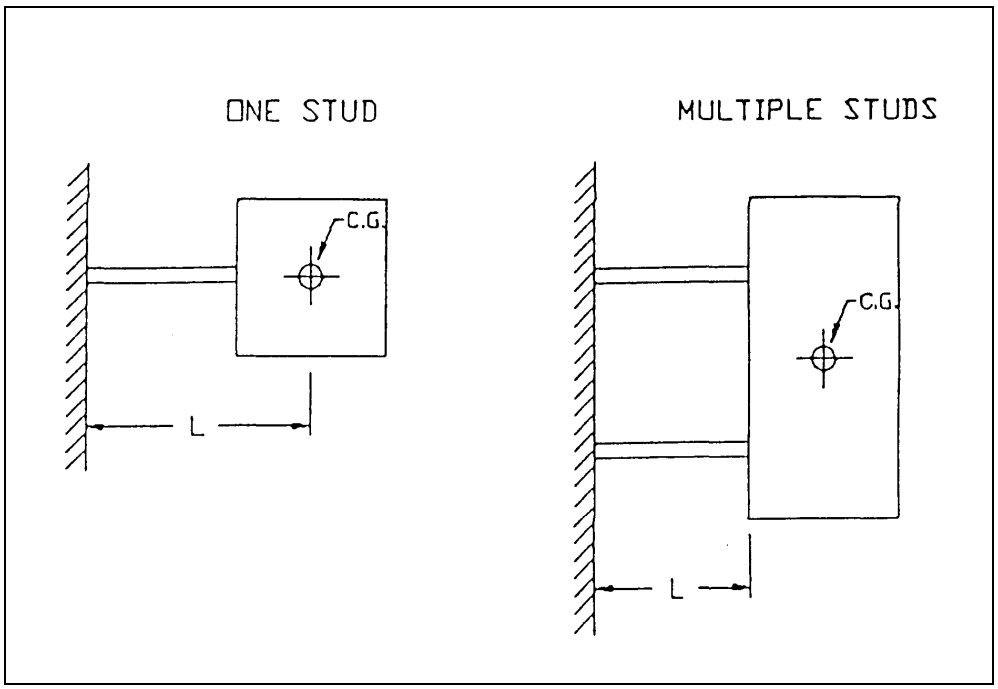


Figure 4-6 — Stud Mounted Equipment

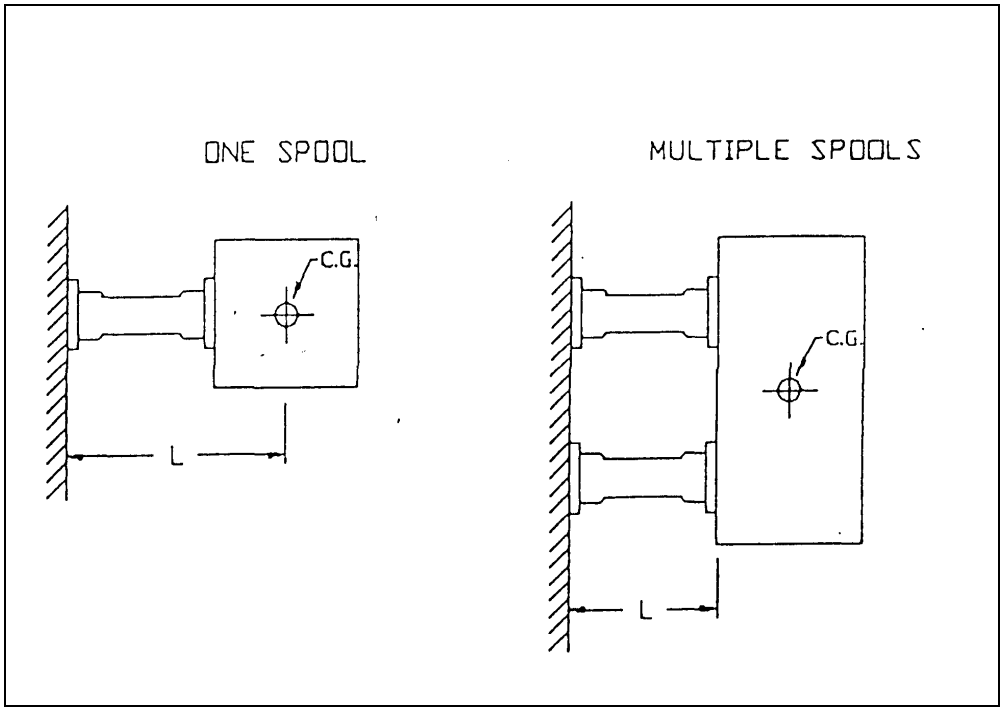


Figure 4-7 — Spool Mounted Equipment

BOUND DISTRIBUTIVE SYSTEM INSTALLATION PARAMETERS

This section report describes and outlines the ranges of various parameters considered for System Installations. The distributive system installation parameters were evaluated and a range for the variables was established which will be used to analyze and develop the standards. The parameters identified earlier were bound by establishing a min/max and increments of the various physical geometry, sizes, arrangements, installation constraints, installation attachments, fastening methods, ship structure interface scenarios, and effects of installations' physical location. The parameters were evaluated for certain representative group of installation types, rather than evaluating specifics of every type of installation. The installation types evaluated fall under three major ship-system categories, namely, Piping, Cable/Wireways, and Ventilation/Ducting. A fourth category was also established, not based on ship-system, but based on ship-structure interface. This category is installations on Joiner Bulkheads.

General parameters like loading, vibration, noise, fatigue, allowable stress, etc., were reviewed, and a preliminary estimation of these parameters was done. Some of these estimations are elaborated in the report of Section 2.B.

The materials for straps, saddles, U-bolts, and studs should be commercial quality carbon steel. The steel should be a weldable grade with a minimum tensile strength of 47 KSI. The material should be capable of being bent at room temperature through 90^{o} to an inside radius equal to the material thickness without cracking on the outside of the bend. Bands, Caps, and Buckles should be electroplated zinc carbon steel or stainless steel. Bolts and Nuts should be regular series hex electroplated zinc type as per ASTM standards or shipyard specifications.

System Installations located in areas subject to corrosion, such as in bilge's, ballast tanks, and areas exposed to the weather, should be zinc-plated or blasted and coated with inorganic zinc or coated with the same material as that of the surrounding area.

Long system runs, such as on the weather deck or in longitudinal passageways which are affected by ship flexing or systems which have considerable thermal growth should consider certain design considerations Criteria to be onsiderated include clearance type hangers and/or have a rider bar or wear strip made of metal, rubber, neoprene or plastic material as deem appropriate attached to or running along the system to prevent chaffing or other damages to the system. In case of excessive thermal growth in the system, the hangers should have means to absorb and allow any thermal distortions and prevent the system for over-stressing.

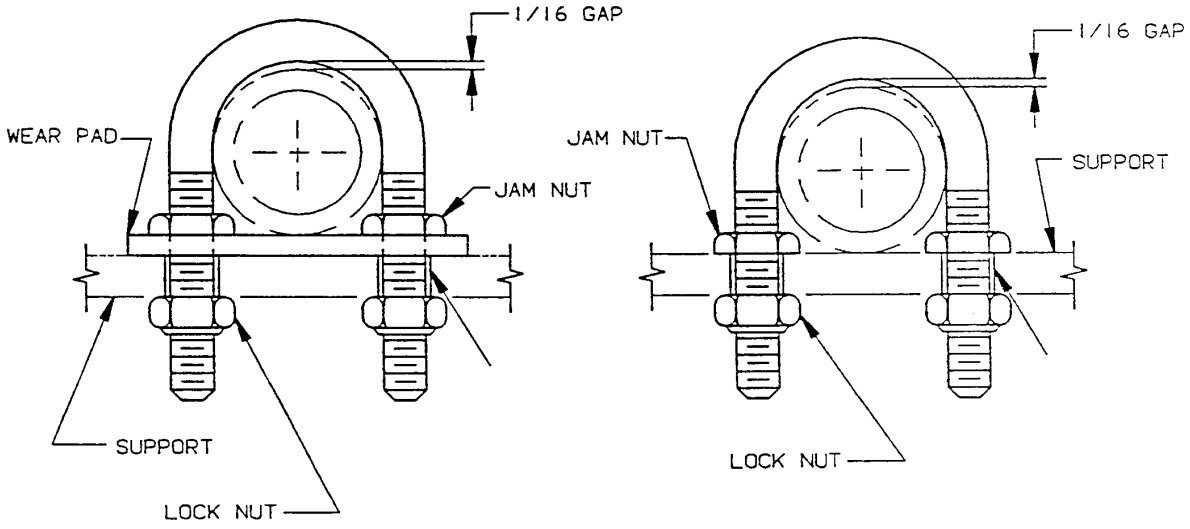
System layout and hanger spacing should be determined at the process modeling stage. The spacing should be governed by the weight of the system, accessories, and fittings, along with the associated fluid and also by the spacing between the ship-structure stiffeners. Special considerations should be given to areas of concentrated loads, such as risers, valves, groups of fittings, branch-off ducts, extra-length coils of cables, and wireways, etc.

PIPING SYSTEMS

INDIVIDUAL PARAMETERS

METHOD 1

U-BOLT ASSEMBLY HANGERS

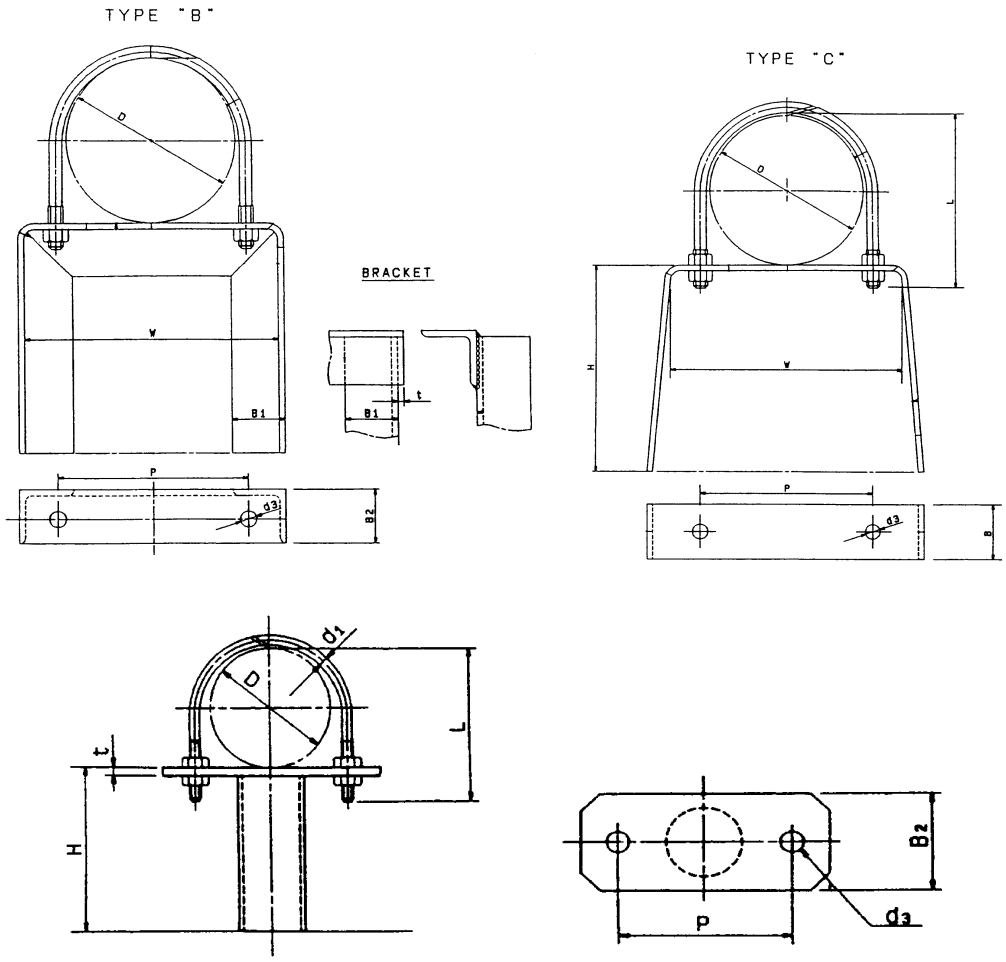


U-BOLT ASSEMBLY WITH WEAR PAD

U-BOLT ASSEMBLY WITHOUT WEAR PAD

U-BOLT ROD DIAMETER	0.25” – 2”
LENGTH OF ROD	5” – 100”
LENGTH OF THREADS	1.5” – 5.5”
INSIDE RADIUS OF U-BOLT	0.3125” – 18.0625”
WEAR PAD THICKNESS	0.25” – 1”
CLEARANCE FOR DISTORTION & THERMAL GROWTH	1/32” – 1/8”

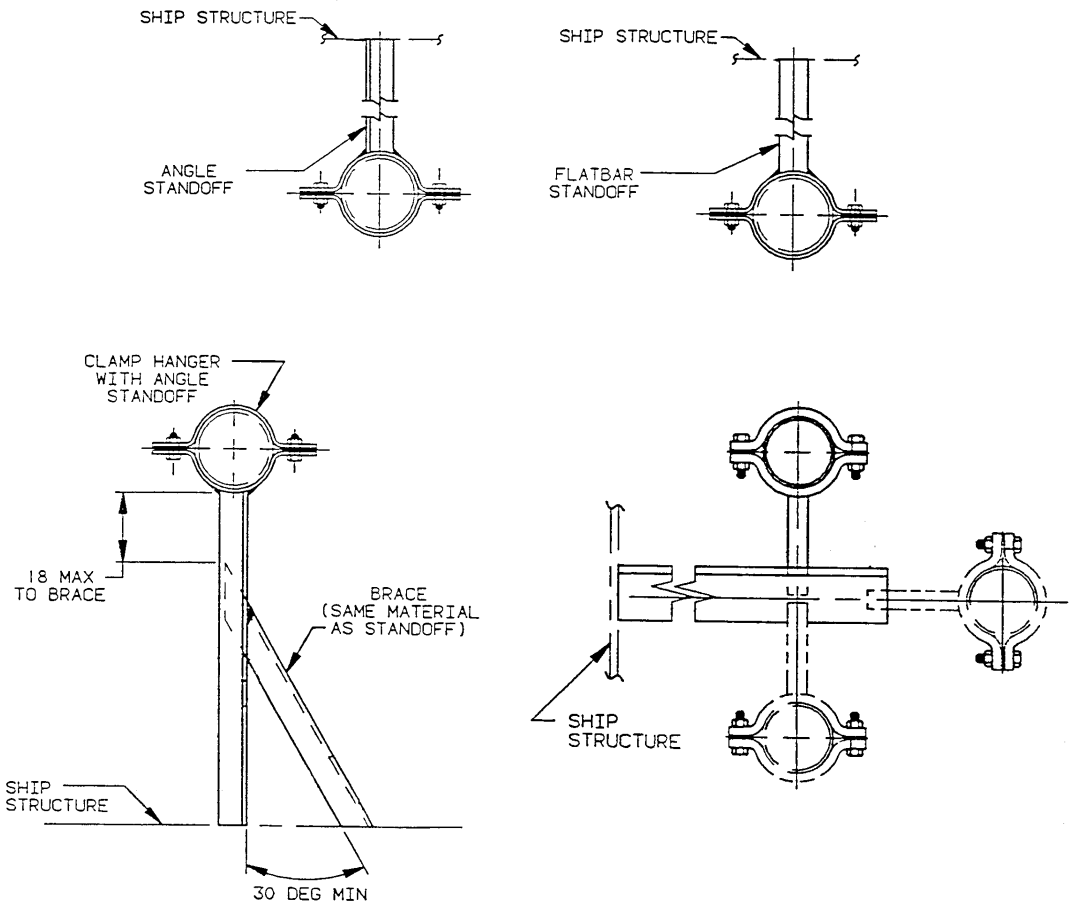
U - BOLT ASSEMBLY W/ STAND-OFF OR STOOL



SAME AS U-BOLT ASSEMBLY AND STOOL ANGLE BRACKET SIZES	1.5”×1.5”×0.1875” – 5”×3”×0.3125”
STOOL FLAT-BAR THICKNESS	1.5”×0.1875” – 4”×0.3125”
STOOL WIDTH	3” – 30”
STOOL HEIGHT	6” – 18”
STAND-OFF PIPE SIZES	1” – 6” (SCH 40 – 80)
STAND-OFF PIPE LENGTH	3” – 12”
SUPPORT PLATE FLAT-BAR SIZES	2”×0.1875 – 4”×0.25”

METHOD 2

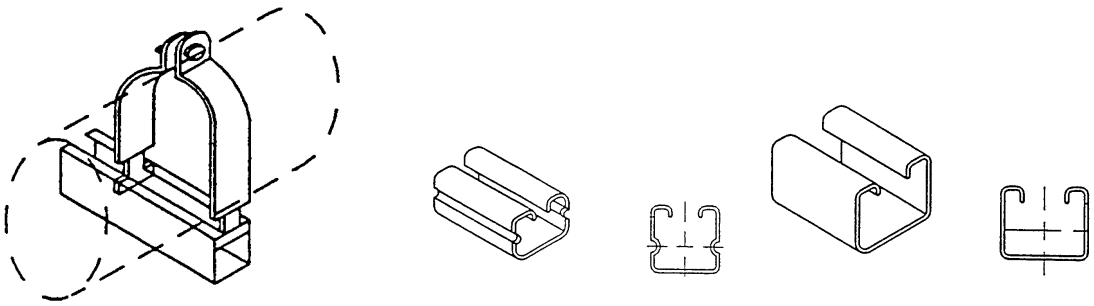
CLAMP HANGERS



CLAMP FLAT BAR SIZES	1”×0.25” – 4×0.75”
LENGTH OF CLAMP FAT BAR	4” – 48”
CLAMP BEND RADIUS	0.375” – 12.1875”
BOLT SIZE	0.375” – 1.375”
STAND-OFF / DOWN-COMER ANGLE SIZE	0.75”×0.75”×0.125” – 4”×4”×0.5”
STAND-OFF / DOWN-COMER FB SIZE	0.75”×0.1875” – 3”×0.5”
STAND-OFF / DOWN-COMER LENGTH	6” – 18”
INSULATION AND LINER/SHIELD CLEARANCES	0.75” – 2.5”

CLEARANCE FOR DISTORTION AND THERMAL GROWTH	1/32” – 1/8”

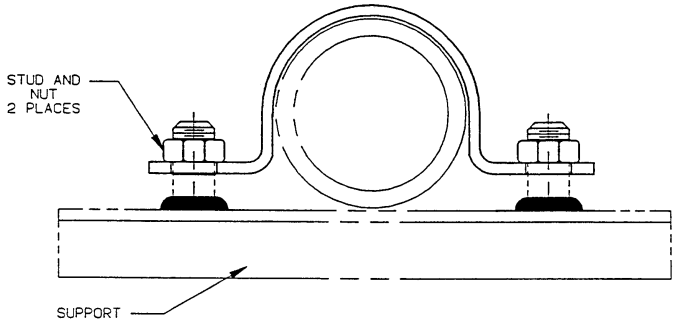
CLAMP AND CHANNEL HANGERS

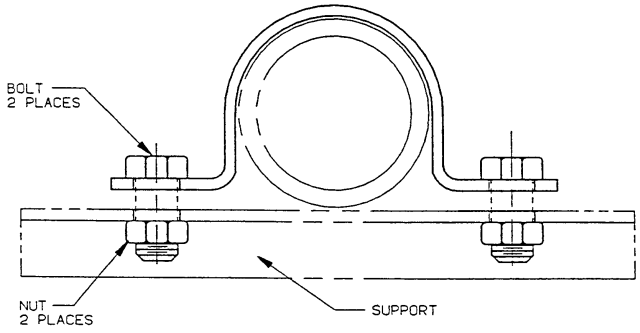


SAME AS CLAMP HANGERS AND CLAMP NECK WIDTH	0.25” – 1”
BOLT / SCREW SIZE	0.375” – 1”
NUMBER OF CLAMPS	1 – 6
CHANNEL (UNISTRUT) SIZES	C2”×0.75”×0.1875” – C4”×2”×0.375”
CHANNEL LENGTH	24” – 120”

METHOD 3

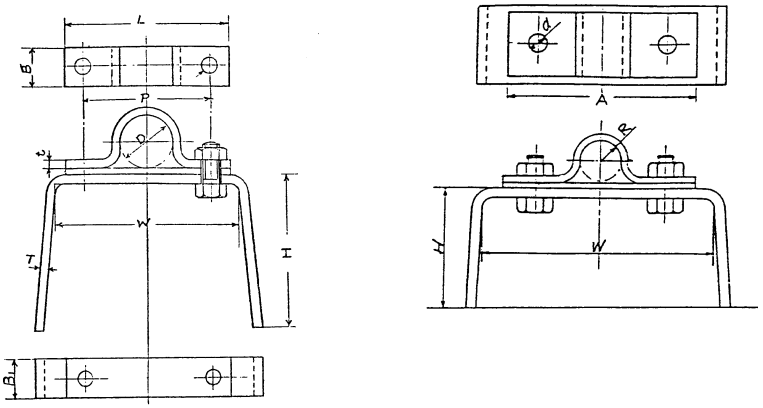
FULL CAP / BAND HANGERS





BAND FLAT BAR SIZES	1”×0.25” – 4×0.75”
BAND FLAT BAR OVERALL LENGTH	4” – 48”
BAND BEND RADIUS	0.375” – 12.1875”
BOLT / STUD SIZE	0.375” – 1.375”

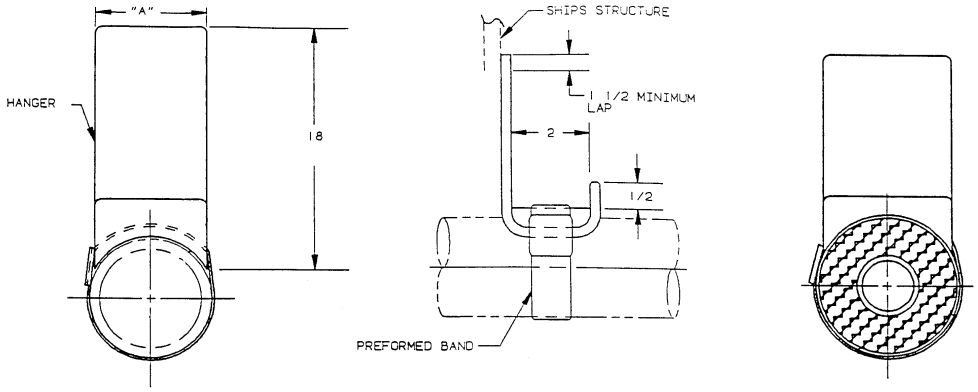
FULL CAP / BAND HANGERS W/ STAND-OFF OR STOOL



SAME AS FULL CAP / BAND HANGERS AND ANGLE BRACKET/FLAT-BAR STOOL – SAME AS U-BOLT ASSEMBLY STAND-OFF OR STOOL

METHOD 4

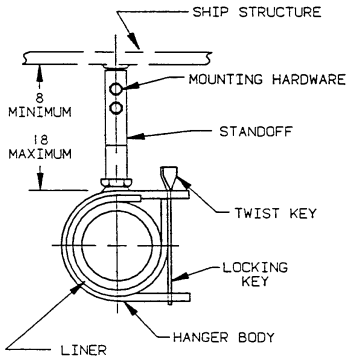
SINGLE LEG "L" BAND HANGER

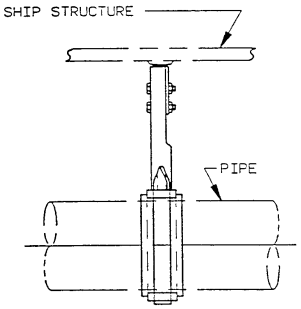


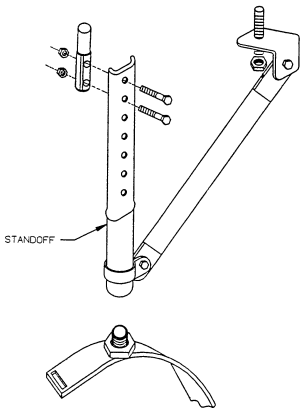
LEG FLAT BAR SIZES	1"×0.125 – 3"×0.25"
LEG LENGTH	6" – 18"
LEG CURVATURE INNER RADIUS TO SUIT CURVATURE OF PIPE SIZES	(0.25" – 6")
PRE-FORMED BAND SIZES	0.5"×1/32" – 1.5"×1/16"
INSULATION AND LINER MATERIAL CLEARANCE	0.75" – 2.5"

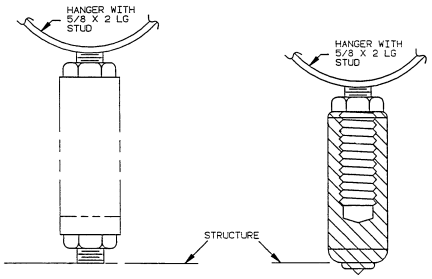
METHOD 5

RTD STUD HANGERS



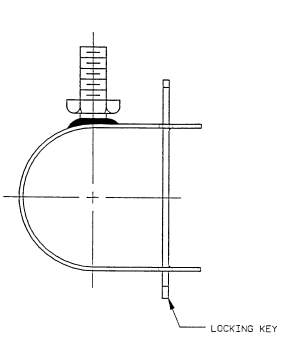


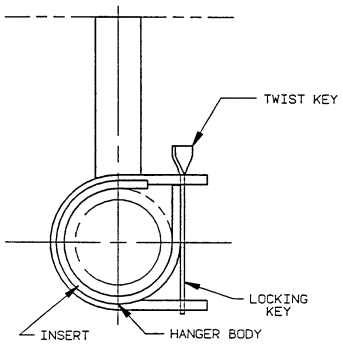


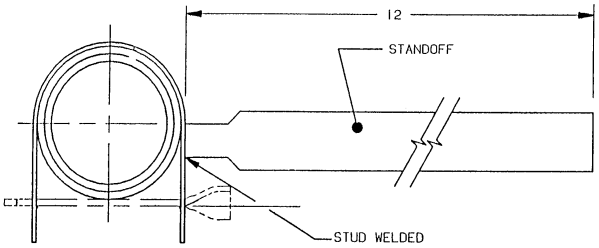


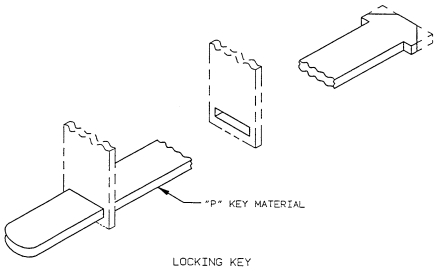
HANGER BODY FLAT BAR SIZES	1”×0.25” – 4×0.75”
STAND-OFF STEEL PIPE SIZES	1” – 4” (SCH 40 – 80)
STAND-OFF LENGTH	3” – 36”
LOCKING KEY FLAT BAR SIZES	0.5”×0.078” – 0.75”×0.125”
LOCKING KEY LENGTH	3” – 6”
BRACE LENGTH (FOR STAND-OFF ≥ 18”)	18” – 36”
BRACE PIPE SIZES	1” – 3” (SCH 40 – 80)
STAND-OFF TO SHIP STRUCTURE CONNECTING STUD SIZE	0.375” – 1.25”
BRACE TO SHIP STRUCTURE CONNECTING STUD SIZE	0.25” – 0.75”
BRACE TO STAND-OFF CONNECTING BOLT SIZE	0.25” – 0.75”

NELSON TYPE HANGERS





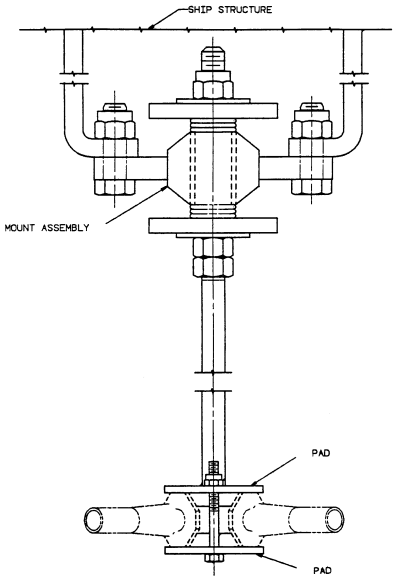


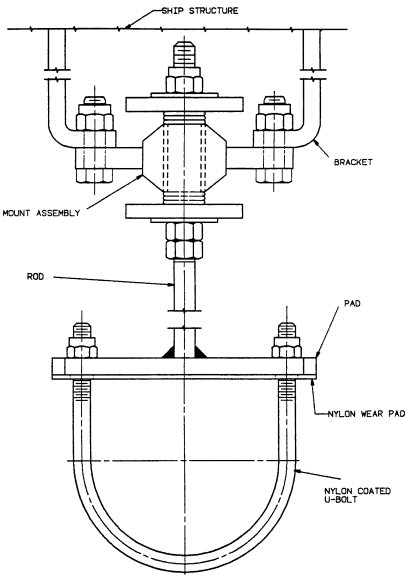


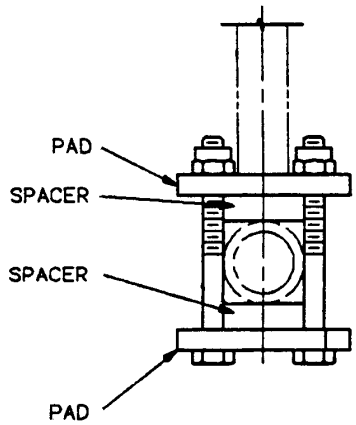
HANGER BODY FLAT BAR SIZES	SAME AS RTD TYPE
STAND-OFF/DOWN-COMER FLAT BAR SIZE	0.75”×0.1875” – 4”×0.5”
STAND-OFF/DOWN-COMER LENGTH	3” – 24”
LOCKING KEY FLAT BAR DIMENSIONS	SAME AS RTD TYPE

METHOD 6

RESILIENT HANGERS





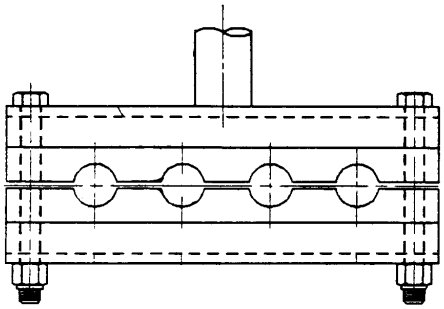


BRACKET FLAT BAR SIZES	1.5”×0.25” – 4”×0.5”
BRACKET LENGTH	6” – 18”
ROD DIAMETER	0.375” – 0.75”
ROD LENGTH	6” – 18”
MOUNTING PAD THICKNESS	0.375” – 0.625”

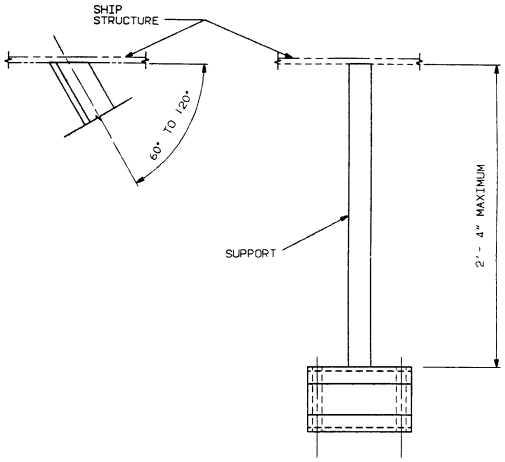
U-BOLT ROD DIAMETER	0.25" – 1"

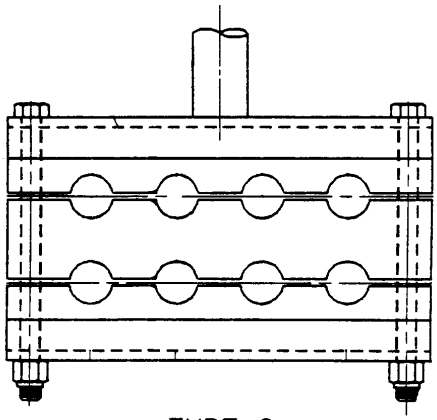
METHOD 7

RUBBER BLOCK HANGERS



TYPE 1
(NEOPRENE, SINGLE)



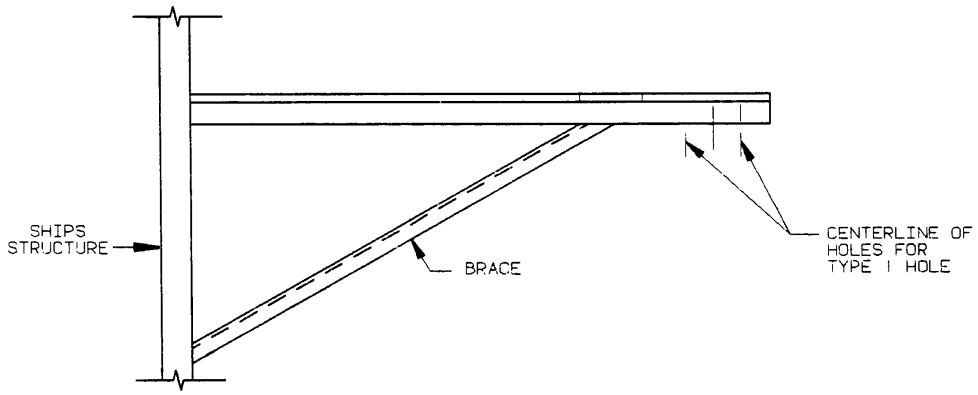


TYPE 2
(NEOPRENE, DOUBLE)

NO. OF TIERS OF PIPING	1 – 2
NO. OF PIPES PER TIER	2 – 4
SUPPORT DOWN-COMER ANGLE SIZES	1.5"×1.5"×0.125" – 3"×3"×0.3125"
SUPPORT DOWN-COMER LENGTH	4" – 18"
BOLT SIZES	0.25" – 0.5"

RUB. BLOCK RETAINER CHANNEL SIZES	C1.5”×0.75”×0.1875” – C3”×1.5”×0.3125”
RUB. BLOCK RETAINER CHANNEL LENGTH	3” – 15”

PIPE HANGER SUPPORTS



PIPE HANGER SUPPORT STRUCTURES ARE NOT CLASSIFIED AS AN INSTALLATION TYPE, SINCE THEY CAN BE INCLUDED IN MANY TYPES OF INSTALLATIONS. THE PARAMETER RANGES TO BE EVALUATED FOR SUPPORT STRUCTURES ARE :

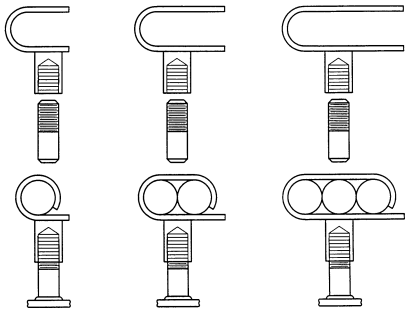
SUPPORT LENGTH	24” – 60”
SUPPORT ANGLE SIZES	2”×2”×0.1875” – 6”×4”×0.5”
PIPE CL AND SHIP STRUCTURE DISTANCE	18” – 48”
BRACE ANGLE (IF ANY)SIZES	2”×2”×0.1875” – 4”×4”×0.5”
BRACE LENGTH	18” – 48”
SUPPORT TO BRACE DISTANCE	24” – 48”
PIPE CL TO BRACE DISTANCE	6” – 12”

ELECTRICAL SYSTEMS

INDIVIDUAL PARAMETERS

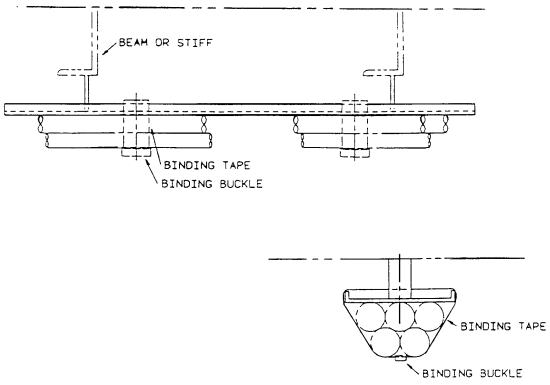
METHOD 1

NELSON STUD CABLE SUPPORT



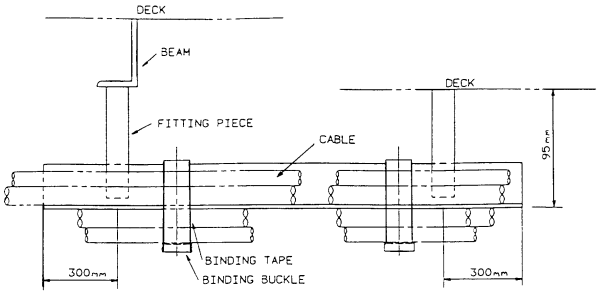
STUD LENGTH	3/16" – 6"
STUD DIAMETER	5/16" – ¾"
PLATING THICKNESS	3/16" – ¾"

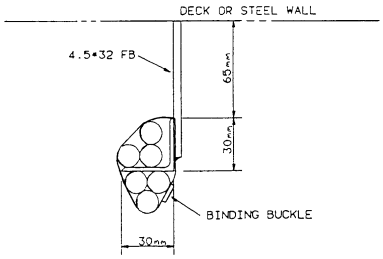
CH TYPE CABLEWAY



FLATBAR DIMENSIONS	2-1/2"×1-1/4"×3/16"–8"×4×1/2"
CHANNEL DIMENSIONS	C3×4.1 – C5×9
PLATING THICKNESS	3/16" – ¾"

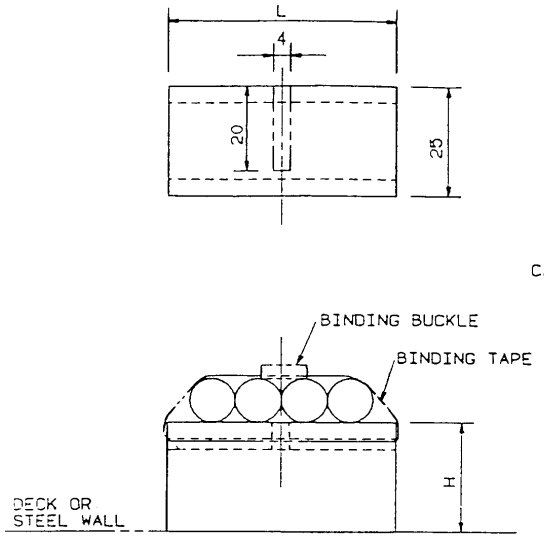
L-TYPE CABLEWAY

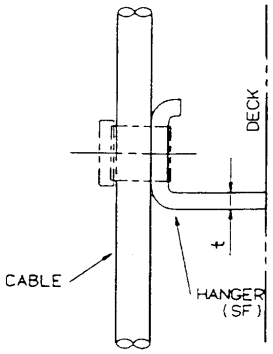




ANGLE DIMENSIONS	1”×1”×1/8”–2”×2”×1/4”
FLATBAR DIMENSIONS	2-1/2”×1-1/4”×3/16”–8”×4×1/2”
PLATING THICKNESS	3/16” – ¾”

HANGER-TYPE CABLEWAY SF, SH



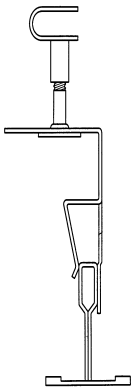


HANGER T	1/8”–1/4”
HANGER L	1-3/16” – 6”
HANGER H	1”–4”
PLATING THICKNESS	3/16” – ¾”

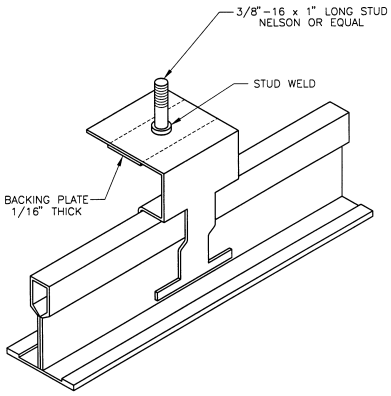
METHOD 2

TYPE A/C T-GRID CEILINGS

METHOD FOR INSTALLING ONE TO FOUR CABLES IN TYPE A OR TYPE C T-GRID CEILINGS



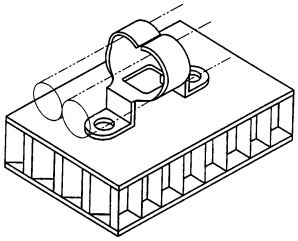
METHOD FOR INSTALLING ONE TO FOUR CABLES IN TYPE A OR TYPE C T-GRID CEILINGS

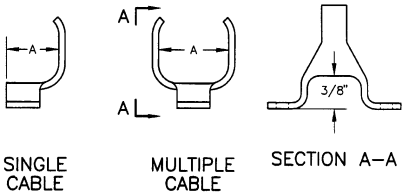


T-GRID THICKNESS	1/16" – 1/8"
BACKING PLATING THICKNESS	1/16" – 1/8"

METHOD 3

HONEYCOMB BULKHEAD HANGER

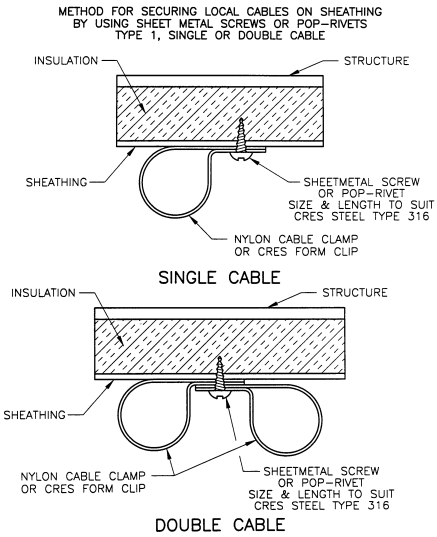




NO. OF LEGS	1 – 2
"A" DIMENSION (CLAMP WIDTH)	.3" – 2.2"
RIVET SIZE	4 – 6
NO. OF CABLES	1 – 4
STANDOFF DISTANCE	3/8" – 3"
PLATING THICKNESS	3/16" – ¾"

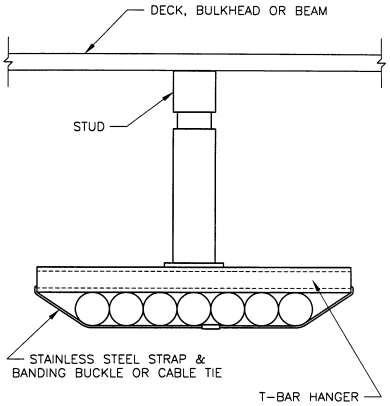
METHOD 4

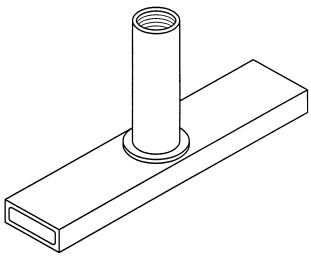
SECURING LOCAL CABLES ON SHEATHING



METHOD 5

TUBULAR HANGERS

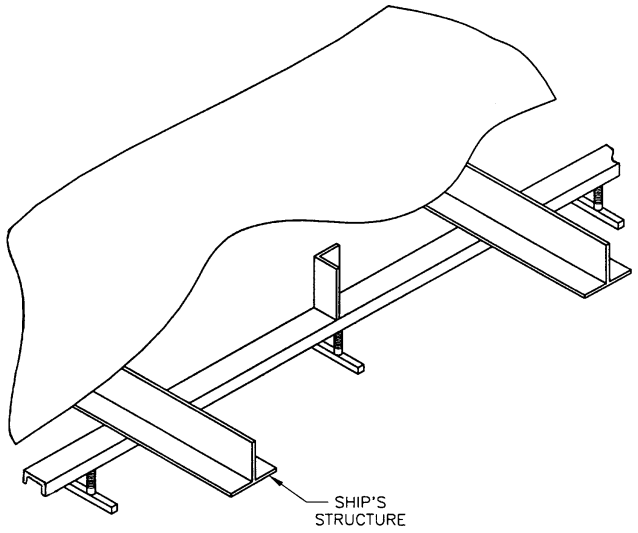




T-BAR SECTION	¼”×1/2” – ½”×1”
T-BAR LENGTH	1-1/2” – 7-1/2”
STUD DIAMETER	¼” – ¾”
STUD LENGTH	7/8” – 6”
PLATING THICKNESS	3/16” – ¾”

METHOD 6

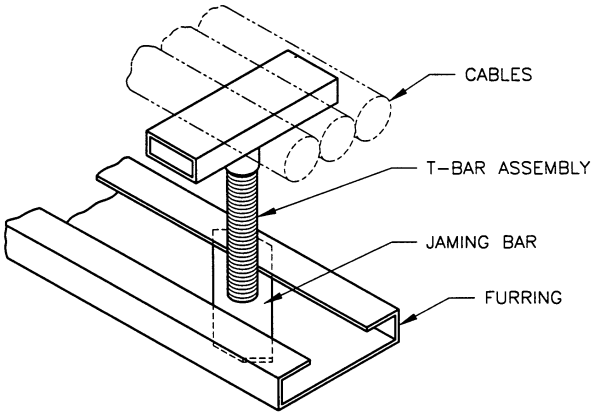
SUPPORTING T-BAR HANGERS ON BULKHEADS USING CHANNEL

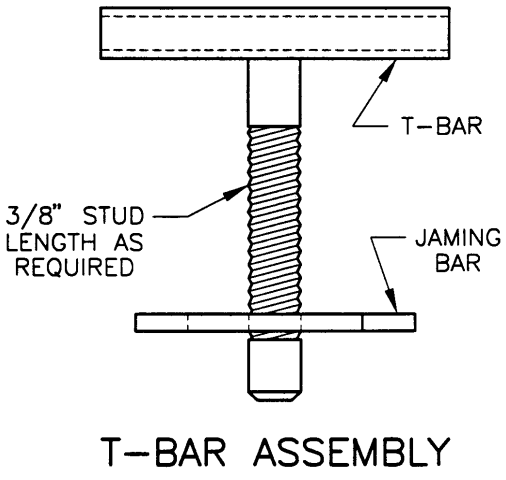


CHANNEL DIMENSIONS	1-1/2"×1/2"×1/8"–3"×1"×1/4"
ANGLE DIMENSIONS	1"×1"×1/8"–1-1/4"×1-1/4"×1/4"

METHOD 7

SUPPORTING CABLES RUNNING ON CEILING FURRING

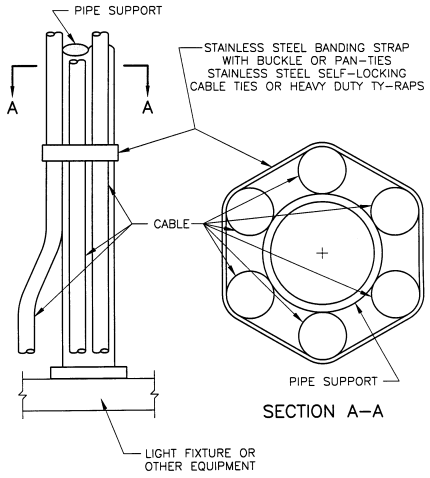




METHOD 8

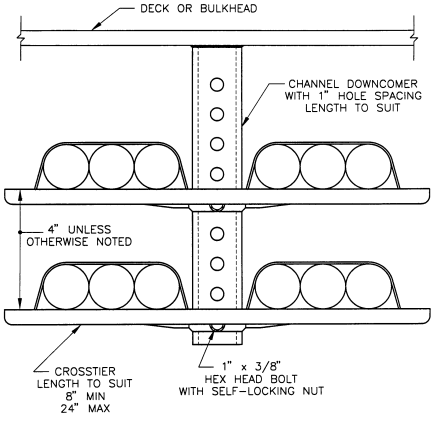
CABLES MOUNTED ON PIPE SUPPORTS

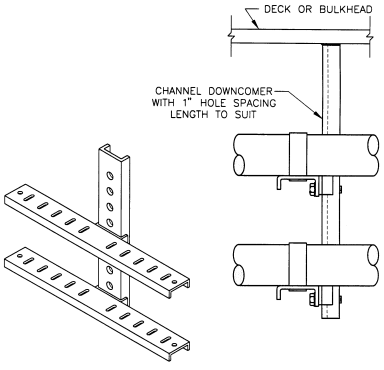
METHOD FOR SUPPORTING UP TO SIX CABLES FOR EQUIPMENT MOUNTED ON PIPE SUPPORTS



METHOD 9

CROSSTIERS ON CHANNEL DOWNCOMER

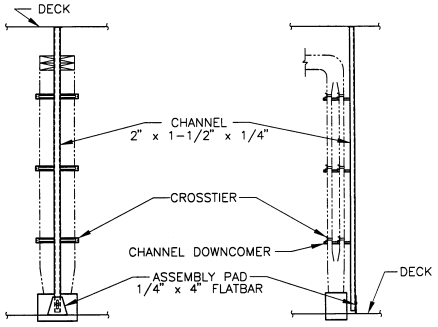




DOWNCOMER DIMENSIONS	1-5/8”×5/8”×3/16”–2”×1”×1/2”
DOWNCOMER LENGTH	4”–30”
CROSSTIER DIMENSIONS	2-1/16”×1-1/8”×1/8”–3”×1-1/2”×1/4”
CROSSTIER LENGTH	8”–24”
PLATING THICKNESS	3/16”–3/4”

METHOD 10

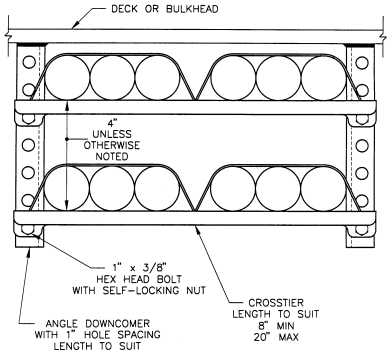
SUPPORTING VERTICAL TIERS OF CABLE INDEPENDENT OF SHIPS STRUCTURE WITH METHOD 9 HANGERS

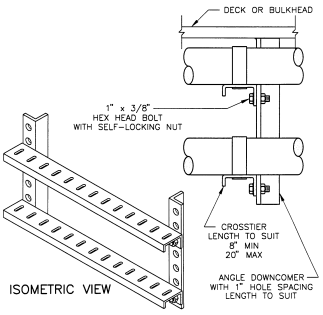


CHANNEL DIMENSIONS	2" X 1-1/2' X 1/4' TO 4" X 1-3/4' X 5/16"
CHANNEL LENGTH	2" TO 20'
ASSEMBLY PAD	1/4" X 4' TO 1/2' X 8"
PLATING THICKNESS	3/16" TO 3/4"

METHOD 11

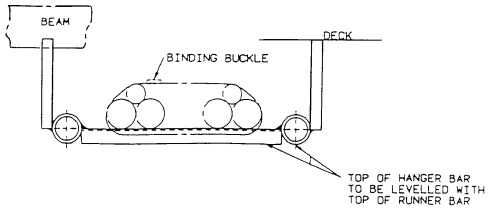
TRAPEZE TYPE CROSSTIERS AND CABLE TROUGHS

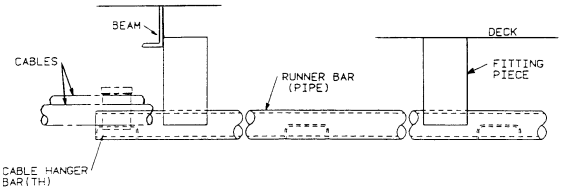




DOWNCOMER DIMENSIONS	1' X 1' X 3/16" TO 1-1/2" X 1-1/2" X 1/4"
DOWNCOMER LENGTH	3-3/8" TO 36-3/8'
CROSSTIER DIMENSIONS	2-1/16" X 1-1/8' X 1/8' TO 3" X 1-1/2" X 1/4"
CROSSTIER LENGTH	8" TO 20'
TROUGH LENGTH	6" TO 72"
PLATING THICKNESS	3/16' TO 3/4'

TRAPEZE WITH PIPE

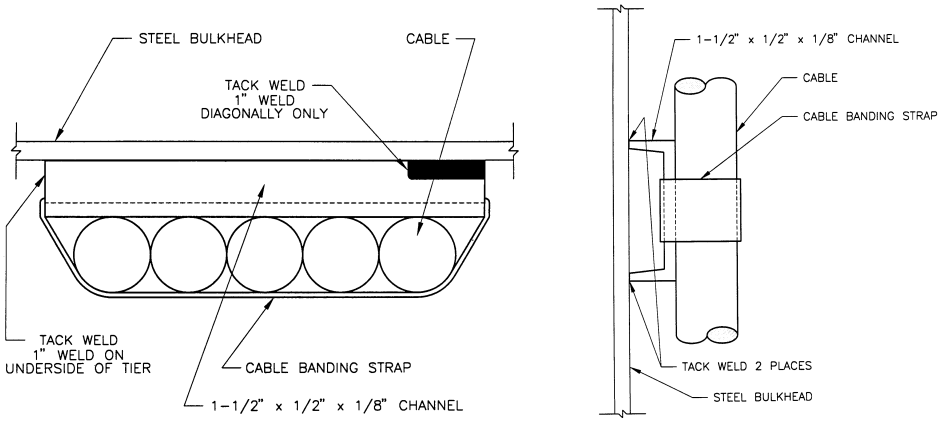




FITTING PIECE DIMENSIONS	2" X 1/4' TO 4' X 1/2'
FITTING PIECE LENGTH	2" TO 20'
HANGER BAR DIMENSIONS	1' X 1' X 1/8" TO 2" X 2" X 1/4"
HANGER BAR LENGTH	8" TO 20"
RUNNER BAR SECTION	1" O.D. TO 4' O.D.
RUNNER BAR LENGTH	6" TO 72"
PLATING THICKNESS	3/16" TO 3/4'

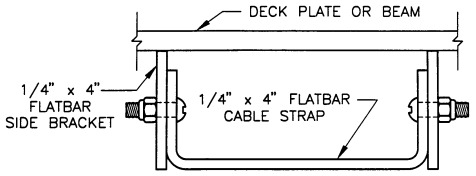
METHOD 12

SUPPORTING CABLES IN DECKS AND BULKHEADS WHERE WIREWAY SPACE IS LIMITED



METHOD 13

SUPPORTING CABLES WITH PORTABLE FLATBAR U-BRACKET



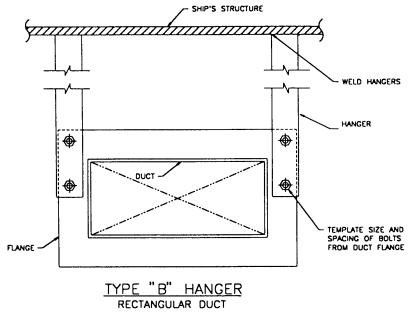
FLATBAR DIMENSIONS	1/4" X 4" TO 1/8" X 4"
FLATBAR LENGTH	2" TO 3'
U-BRACKET SECTION	1/4" X **4**" TO 1/8' X 4'
U-BRACKET LENGTH	8" TO 20"
U-BRACKET DEPTH	4" TO 36'
PLATING THICKNESS	3/16" TO 3/4"

VENTILATION / DUCTING SYSTEMS

INDIVIDUAL PARAMETERS

METHOD 1

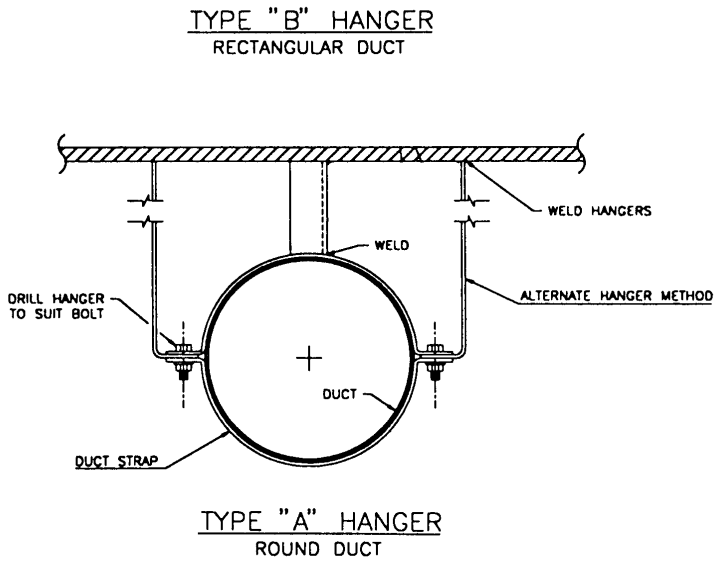
ANGLE/FLAT BAR DOWN-COMER HANGERS



DOWN-COMER ANGLE SIZES	1.25”×1.25”×0.1875” – 3”×3”×0.375”
DOWN-COMER FLAT-BAR SIZES	1.5”×0.25” – 4”×0.5”
DOWN-COMER LENGTH	6” – 48”
LATERAL SPACING BETWEEN DOWN-COMERS	12” – 48”

BOLT SIZE	0.25” – 0.625”

ANGLE/FLAT BAR DOWN-COMER W/ CLAMPS HANGERS



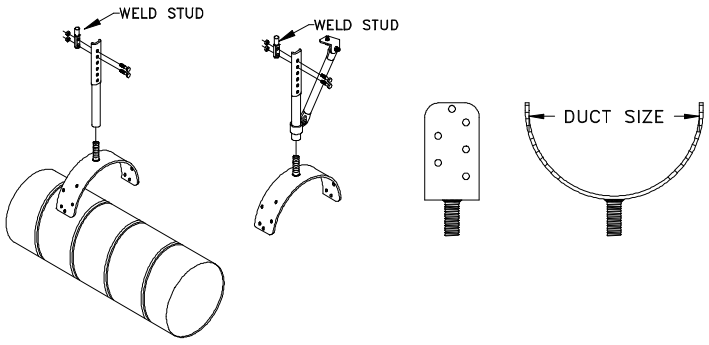
SAME AS ANGLE/FLAT BAR DOWN-COMER HANGERS

CLAMP/STRAP FLAT-BAR SIZES	1”×0.125” – 2”×0.25”

METHOD 2

RTD DUCT HANGERS

ROUND DUCT HANGER



HANGER BODY FLAT BAR	2”×0.25” – 4”×0.5”
STAND-OFF STEEL PIPE LENGTH	6” – 36”
STAND-OFF STEEL PIPE SIZES	SAME AS RTD PIPE HANGERS
HANGER TO DUCT ATTACHING BOLT SIZE	0.25” – 0.625”
BRACE (IF ANY) LENGTH	18” – 30”
BRACE PIPE SIZE	SAME AS RTD PIPE HANGERS
STAND-OFF TO SHIP STRUCTURE CONNECTING STUD SIZE	SAME AS RTD PIPE HANGERS
BRACE TO SHIP STRUCTURE CONNECTING STUD SIZE	SAME AS RTD PIPE HANGERS
BRACE TO STAND-OFF CONNECTING BOLT SIZE	SAME AS RTD PIPE HANGERS

RTD LARGE VENT HANGERS

SAME AS RTD DUCT HANGERS

METHOD 3

RESILIENT DUCT HANGERS	
DOWN-COMER FLAT BAR SIZES	1.25”×0.1875” – 2.5”×0.3125”
DOWN-COMER ATTACHMENT STUD SIZES	0.25” – 0.5”
DUCT CLAMP FLAT BAR WIDTH AND THICKNES	SAME AS DOWN-COMER W/ CLAMPS HANGERS
DUCT CLAMP FASTENING BOLT SIZE	SAME AS DOWN-COMER W/ CLAMPS HANGERS

The parameters of various system installation types and their respective min/max and ranges will be used as the starting point for the engineering analysis and standards development.